Investigation on the Standard for Energy and Environmental Design of Residential House in China

Yumiko Ogawa*[1], Weijun Gao[2], Nan Zhou[3], Toshiyuki Watanabe[4], Hiroshi Yoshino [5] and Toshio Ojima[6]

[1] Graduate School, Faculty of Environment Engineering, The University of Kitakyushu
[2] Associate Professor, Faculty of Environment Engineering, The University of Kitakyushu
[3] Researcher, Lawrence Berkeley National Laboratory
[4] Professor, The University of Kyushu
[5] Professor, The University of Tohoku
[6] Professor, Department of Architecture, Waseda University

Abstract

In this research, the authors have carried out the research to investigate the characteristics of building energy standards of the residential building in China. Efforts have also been made to promote a better understanding of the energy policy and relevant standard for architects and building designers to achieve optimal energy efficient building design in China. The results can mainly summarized as follows:(1) As for the thermal environment design, the climate of China has been classified five zones.(2) The sunlight, lighting, ventilation environment of residential building have been specified in the new standards.(3) Prescribed the building design elements, such as layout, orientation, shape, color, plan and the type of window. In particular, the thermal insulation measures for heating system has been added in hot summer and cold winter region, which was not described in old standard.(4) It is admitted that there is still a difference compared with the standard of many foreign countries, and the improvement in the further heat insulation performance and positive execution of the standard continue to be expected.

Keywords: China; residential building; energy conservation; environmental design; standard

1. Introduction

In recent years, China has had significant development on construction sector. Particularly the residential house has been constructing. In 1996, the constructed amount of residence is 2 1,221,880,000m^2 in the whole country. Moreover, the target of residence construction is that the habitation area of a three-person household arrived 81m^2 in 2010 with 3,300 million m^2 in urban and 5 billion m^2 (500 million m^2 per year increased) in rural, this area is the 1.5 times than now.

However, many of the residential building have poor insulation and indoor thermal environment. The remarkable increasing of air-conditioner usage will cause large energy consumption and urban heat island phenomenon in city. In the face of these problems, China has revised the residential building energy code and standard for the energy efficiency design of building envelope and space heating for new construction and expansion of residential building. In this research, the authors have carried out the research to investigate the characteristics of building energy standards of the residential building in China. Efforts have also been made to promote a better understanding of the energy policy and relevant standard for architects and building designers to achieve optimal energy efficient building design, and also for assuming the building energy consumption, assessment of the thermal environment in China.

*Contact Author: Yumiko Ogawa, Graduate School, Faculty of Environment Engineering, The University of Kitakyushu
1-1 Hibikino, Wakamatsu, Kitakyushu,
Fukuoka,808-0135, Japan
Tel.:+81-93-695-3234 Fax: +81-93-695-3335
e-mail: d3640101@hibikino.ne.jp
(Received March 1, 2003 ; accepted July 1, 2004)

2. Outline of standard of energy conservation in China

In this paper, the research has been done by mainly using [Code of Design for Residential Building], [Thermal Design Code for Civil Building], [Technical Code for Renovation of Existing Heating Residential Buildings], and [Design Standard For Energy Efficiency Of Residential Building In Hot Summer And Cold Winter Zone] [1-8]. Moreover, in order to have a comparison, the Japanese standard for rationalization of energy consumption in residential houses has also been presented in Table one.

In China, the three types of civil building can be classified as following: (1) the buildings with a long-time use, such as residential building, nursery, kindergarten, medical-treatment institute, hospital; (2) the buildings with an intermittent use, such as: office,

school. (3) the buildings with an intermittent use which has lower heat demand than (1) type and (2) type, such as hall, dining-room, gymnasium, theater and airport. Moreover, the residential building includes residence, lodgings, hotel and so on.

There are four standards for energy conservation and thermal environment improvement on national level in China, as are shown in Table 1. Those standard mainly described the indoor thermal environment, measurement to decrease of heating load and the energy conservation in severe cold region, cold region and hot summer, and cold winter region. There is no standard for hot summer and warm winter region or warm region. However, there are some non-national standards. Some province and cities have specified the standard suitable for special climate and economic level. Among these standards, “energy conservation design standard for residential building in Shanghai” (DG/TJ08-205-2000) has been used as the standard for high economic area in hot summer and cold winter region.

Table 1. Standard of energy conservation for residential building

	Name of Standard	Application Case	Comparison
Japan	Standard for rationalization of energy consumption in Residential Houses	Town House, Complex residence, Apartment, Detached house	the energy conservation of residential building for six regions have been described
China	Thermal Design Code for Civil Building (GB50176-93) ⇒thermal standard Design code for heating, ventilation and air consitioning (GBJ19-87)⇒heating supply standard	new, reforming and extending building; not include basement, room with special temperature demand, residence with special use and simple hypothetical residence	Described the indoor thermal environment, decrease of heating load and the energy conservation in severe cold region, cold region and hot summer & cold winter region; not described the standard for hot summer and warm winter region or warm region. However, there are some non-national standards. Some province and citie have specified the standard suitable for special climate and economic level. Among these standards, "energy conservation design standard for residential building in Shanghai" (DG/TJ08-205-2000) has been used as the standard for high economic area in hot summer and cold winter region.
	Energy conservation design standard for residential building (JGJ26-95) ⇒heating residence standard	new and extend heating residential building in severe cold region and cold region.	
	Design standard for energy efficiency of residential building in hot summer and cold winter zone (JGJ134-2001) ⇒hot summer and cold winter standard	new and extend heating residential building in hot summer and cold winter region.	

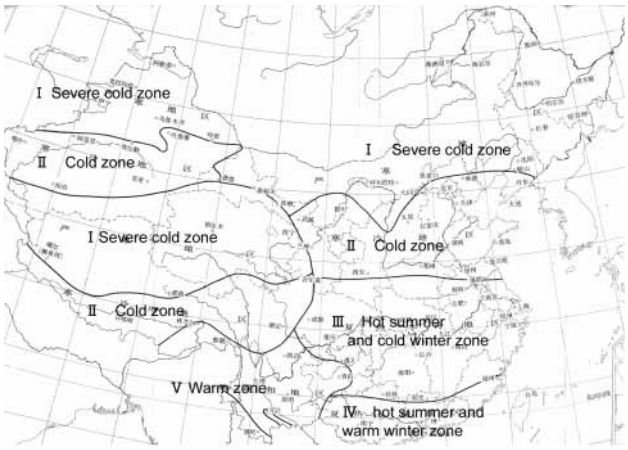

Fig.1. Climate zoning in China

3. The climate classification in the thermal environmental design of building

China is a large country with a range of climates varying from tropical to cold temperate; it has been classified into five zones shown in Figure one and Table two in the thermal environmental design of building. The zoning was based on the two indexes, main index and auxiliary index. Main index was defined as a monthly average air temperature in the coldest month or hottest month. Auxiliary index was defined as a day number in which daily air temperature was higher than 25˚C or lower than 5˚C. For example, cold zone II is an area that the monthly average temperature ranges between 0~-10˚C in the coldest month with about 90~145 days in which the daily average temperature is lower the 5˚C. Severe cold zone I and cold zone II have been called heating region conventionally which mainly includes the northeast China, north China, and southwest China. And those zones account for 70% area of the whole country. However, many residential building in those zones have not satisfied with the demand of energy conservation design standard for civil building. Although the 13 billion m^2 residence floor area has been built from 1979 to 1996 in the whole country, only 40 million m^2 is energy-saving building.

On the other hand, since hot summer and cold winter region III was defined a non-heating area by government,

Table 2. The classification in the thermal environmental design of building

	region	Standard of China		Japan
		Main index	Auxiliary index	Degree days
I	severe cold zone	outdoor average air temperature of coldest month≦-10℃	days of dayly average temperature ≦5℃ is ≧145d	≧3500
II	cold zone	outdoor average air temperature of coldest month0℃～-10℃	days of day average temperature ≦5℃ is 90～145d	3000～3500
III	hot summer and cold winter zone	average temperature of coldest month is 0℃～-10℃ and average temperature of hotest month is 25℃～30℃	days of day average temperature ≦5℃ is 0～90d days of day average temperature ≧25℃ is 40～	2500～3000
IV	hot summer and warm winter zone	average temperature of coldest month is >10℃ and average temperature of hotest month is 25℃～29℃	days of day average temperature ≧25℃ is 100～200d	1500～2500
V	warm zone	average temperature of coldest month is 0℃～13℃ and average temperature of hotest month is 18℃～25℃	days of day average temperature ≦5℃ is 0～90d	500～1500
VI				≦500

the shelter thermal property of building was poor and air conditioning equipment was not installed. However, summer is very hot and winter is very cold in this region. In recent years with the economy development, air-condition in summer and heating in winter has become general. Moreover, this region includes the Yangtze River valley and circumference area of this valley, such as Shanghai, Chongqing, added up to 16 provinces and

autonomous. In this region, it is about 1,800,000 square kilometers with 550 millions Populations and also its GDP occupied 48% of the whole country. crowded population and developed economy are the characteristics of this region. The energy conservation design and the low environment load in construction is an urgent subject, and the standard need to be revised greatly.

4. Design standard in residential building

In the new standard, it has been described as elements such as sunshine, lighting, and the ventilation environment. First about the sunshine standard, it follows the residence sunshine standard of present national standard [standard design for residence community in city] (GB50180). As about the lighting standard has been shown in Table.3. Furthermore, in order to guarantee the ventilation of room, the vent area was shown in Table.4. And also, in the severe cold region and only one orientation residence, the ventilation equipment should be installed in bedroom and living room; the natural ventilation way should be installed in kitchen and bathroom.

5. Energy conservation standard

5.1 Standard for construction

Layout and orientations: Buildings are suitable to be designed in south-north orientations or close to that. It will be located in sunlight and avoid prevailing wind direction, and the ventilation property should be good. About the windows in the side of face to sun, especially the west and east sides, some sunshade measures should be adopted, such as, exterior corridors, veranda, and eave. Main rooms should avoid an east and west orientation. In cold zone II, hot summer and cold winter zone III and hot summer and warm winter zone IV, the west orientation windows of a room must to take sunshade measures, and the insulation measures must be taken in the roof and west exterior wall.

Shape: It should reduce building external surface area, and the main building should avoid too much concave-convex part. The shape coefficient of the building has been shown in Table.5. The shape coefficient of building is that ratio of exterior surface area of building exposing to the air to the volume enclosed by it.

Plan: Residential building should avoid the open staircases and outside corridor; it is also necessary to make windows area as small as possible, to reduce crevice length of windows, and to raise air tightness in the severe cold zone and cold zone. The various heat transfer coefficient of window about different orientation and ratio of windows to wall have been shown in Table.5. Moreover, the double sliding window is suitable for building with high stories, and it needs to install a movable type sunshade for window.

Color: Building should take the building material with shallow color. If possible, especially a flat roof needs to take heat insulation measures, such as roof planting in hot summer and cold winter region.

Windows: In the case of conventional glass, the ratio of windows to wall should be below 0.3 and in the pair-glass, the ratio should not exceed 0.4. The side faced to sun, especially the west and east orientation windows must take sunshade measures, such as heat reflected glass, movable bride, and windows can be made to partial opening and closing.

Table 3. Standard of lighting for residential building

room	Side light	
	limitation of Lighting coefficient	Area ratio of windows to floor
bedroom, living room, kitchen	1	1/7
staircases	0.5	1/12

Table 4. Standard of ventilation area

room	ventilation area
bedroom, living room, bathroom	≧1/20 of floor area
kitchen	≧1/10 of floor area and ≧0.6m^2

Table 5. Shape coefficient of building of different zone

Zone	Shape	Shape coefficient of building
hot summer and cold winter region Ⅳ	line type	below 0.35
	point type	below 0.40
severe cold region and cold region Ⅰ、Ⅱ		below 0.30

Table 6. Heat transfer coefficient of window

Orientations of window	Environment situation of outdoor	Heat transfer coefficient of window				
		area ratio ≦0.25	0.25＜ area ratio ≦0.30	0.30＜ area ratio ≦0.35	0.35＜ area ratio ≦0.45	0.45＜ area ratio ≦0.50
North	coldest outdoor average air temperature in winter >5℃	4.7	4.7	3.2	2.5	
	coldest outdoor average air temperature in winter ≦5℃	4.7	3.2	3.2	2.5	
West and East	no sunshade measure	4.7	3.2			
	with sunshade measure	4.7	3.2	3.2	2.5	2.5
South		4.7	4.7	3.2	2.5	2.5

Table 7. Heat transfer coefficient and heat resistant index of shelter

exterior wall	window glass (including balcony door)	partition wall and floor	floor with under ventilation	door
K≦1.5 D≧3.0	follow the standard	K<=2.0	K<=1.5	K<=3.0
K≦1.0 D≧2.5				

Notes:

(1)Since the heat transfer coefficient of exterior wall is influenced with the heat bridge of structure, the value in this table is averaged value of exterior wall.

(2)If the exterior wall and roof satisfy the heat transfer coefficient value and not satisfy heat resistant index value, it should to verify the requirement for thermal insulation design according to prescription 5.1.1 of [Specification for thermal design of civil building] (GB50176-93).

(3)D is the heat resistant index that is the shelter resistant to heat transfer and temperature. The value of D is the integral of multiplication of heat resistant coefficient R and thermal storage integration for various materials. D=ΣR・S; unit is W/m^2・K.

Table 8. Heat transfer coefficient limitation values

Outdoor mean air temperature during heating period (°)	Representative cities	roof		exterior walls		staircases without		windows (including upper part of balcony)	lower part of balcony door	exterior door	floor broad		ground floor	
		shape coefficient ≦0.3	shape coefficient >0.3	shape coefficient ≦0.3	shape coefficient >0.3	partition	house door				floor broad exposed to the air	floor broad over basement without heating	perimeter	non-perimeter
2.0～1.0	Zhengzhou, Luoyang, Baoji, Xuzhou	0.80	0.60	1.10 1.40	0.80 1.10	1.83	2.70	4.70 4.00	1.70	1.00	0.60	0.65	0.52	0.30
0.9～0.0	Xian, lasha, Jinan, Qingdao, Anyang	0.80	0.60	1.00 1.28	0.70 1.00	1.83	2.70	4.70 4.00	1.70	1.00	0.60	0.65	0.52	0.30
-0.1～-1.0	Shijiazhuang, Dezhou, Jinchen, Tianshui	0.80	0.60	0.92 1.20	0.60 0.85	1.83	2.00	4.70 4.00	1.70	1.00	0.60	0.65	0.52	0.30
-1. 1～-2.0	Beijing, Tianjin, Dalian, Yangquan, Pingliang	0.80	0.60	0.90 1.16	0.55 0.82	1.83	2.00	4.70 4.00	1.70	1.00	0.50	0.55	0.52	0.30
-2. 1～-3.0	Lanzhou, Tianyuan, Tangshan, Aba, Kashi	0.70	0.50	0.85 1.10	0.62 0.78	0.94	2.00	4.70 4.00	1.70	1.00	0.50	0.55	0.52	0.30
-3 .1～-4.0	Xining, Yinchuan, Dandong	0.70	0.50	0.68	0.65	0.94	2.00	4.00	1.70	1.00	0.50	0.55	0.52	0.30
-4.1～-5.0	Zhangjiiakou, Anshan, Jiuquan, Yining, Tulufan	0.70	0.50	0.75	0.60	0.94	2.00	3.00	1.35	1.00	0.50	0.55	0.52	0.30
-5.1～-6.0	Shengyang, Datong, Benxi, Fuxin, Hami	0.60	0.40	0.68	0.56	0.94	1.50	3.00	1.35	1.00	0.40	0.55	0.30	0.30
-6.1～-7.0	Huerhate, Fushun, Dachaidan	0.60	0.40	0.65	0.50			3.00	1.35	2.50	0.40	0.55	0.30	0.30
-7.1～-8.0	Yanji, Tongliao, Tonghua, Siping	0.60	0.40	0.65	0.50			2.50	1.35	2.50	0.40	0.55	0.30	0.30
-8.1～-9.0	Changchun, Wuhunuqi	0.50	0.30	0.56	0.45			2.50	1.35	2.50	0.30	0.50	0.30	0.30
-9.1～-10.0	Haerbin, Mudanjiang, Kelamayi	0.50	0.30	0.52	0.40			2.50	1.35	2.50	0.30	0.50	0.30	0.30
-10.1～-11.0	Jiamusi, Anda, Qiqihaer, Fujin	0.50	0.30	0.52	0.40			2.50	1.35	2.50	0.30	0.50	0.30	0.30
-11.1～-12.0	Hailun, Boketu	0.40	0.25	0.52	0.40			2.00	1.35	2.50	0.25	0.45	0.30	0.30
-12.1～-14.5	Yichun, Hluna, Hailaer, Manzhouli	0.40	0.25	0.52	0.40			2.00	1.35	2.50	0.25	0.45	0.30	0.30

Notes:

1. In the table heat transfer limitation values of exterior walls are mean heat transfer coefficients of exterior walls with the consideration of effect of peripheral heat bridges. For some regions two lines of data are illustrated, the values of upper line are corresponding with heat transfer coefficient of 4.70 of single plastic window; while the values of lower line are corresponding with heat transfer coefficient of 4.00 of double glazing metal window.
2. In the table, in the column of "perimeter ground", 0.52 is heat transfer coefficient of concrete ground without thermal insulation layer of building periphery, and 0.30 is heat transfer coefficient of concrete ground with thermal insulation layer. In the column of "non-perimeter ground", 0.30 is heat transfer coefficient of concrete ground without thermal insulation layer beyond building periphery.

5.2 Standard for insulation

Thermal property: Heat-protection calculation should be carried for the exterior wall, roof, the slab exposed to out air and staircases without heating and so on, and also the heat resistance of these parts should be satisfied the standards for different region. Thermal insulation measures should be taken for the locations of building envelope with heat bridge according to calculation. In the severe cold region, the building periphery of the first floor should adopted the heat protection measures, and the inside temperature of roof, east wall and west wall must satisfy the requirements for thermal insulation design in summer.

Table 6 and Table 7 have shown the thermal property of different building part. On this standards, each province and municipality have also enacted the standard for various regions. The heat transfer coefficient limitation values of different region for renovation of existing heating residential buildings have been shown in Table 8. Furthermore, this standard is also suitable for new residential building.

Table 9 is the heat transfer coefficient values of building shelter in different countries. As this

Table 9. Heat transfer coefficient standard for different country

country	region		roof	exterior wall
China	Ⅰ		0.25-0.4	0.4-0.52
	Ⅱ		0.4-0.6	0.56-0.68
	Ⅲ		0.6-0.8	0.8-1.1
	Ⅳ		0.8-1.0	1.0-1.5
	Ⅴ		1	1.5
Japan	Ⅰ	housing corporation standard	0.6	0.7
		new energy conservation	0.23	0.42
		next-generation standard	0.32	0.49
	Ⅱ	housing corporation standard	0.9	1
		new energy conservation	0.51	0.77
		next-generation standard	0.41	0.58
	Ⅲ	housing corporation standard	0.9	1
		new energy conservation	0.66	0.77
		next-generation standard	0.43	0.86
	Ⅳ	housing corporation standard	1	1.3
		new energy conservation	0.66	0.77
		next-generation standard	0.43	0.86
	Ⅴ	housing corporation standard	1.3	-
		new energy conservation	0.66	0.87
		next-generation standard	0.43	0.86
South Sweden	include Stockholm		0.12	0.17
Canada	DegreeDay>3500		0.17(Inflammability) 0.30(non-	0.27
	DegreeDay=3000-3500		0.23(Inflammability) 0.40(non-	0.38
Denmark			0.2	0.3 (weigth<=100kg/m^2) 0.35 (weight>100kg/m^2)
British			0.45	0.45
Germany			0.22	0.5

Table 10. Heat property of floor for heating residential building

Zone	B value $W/(m^2 \cdot h^{-1/2} \cdot K)$	Attribute of building
Ⅰ	＜17	senior residential building, nursery, kindergarten, Medical-treatment institution
Ⅱ	17～23	general residential building, office, school
Ⅲ	＞23	air temperature is larger than 23℃ and Short-time stay room

Notes: B is calculated according to the position of material influencing on the heat absorption of floor

Table 11. Air permeability grade values standard from Gb7107-86

grade	Ⅰ	Ⅱ	Ⅲ	Ⅳ	Ⅴ
limitation value($m^3/m \cdot h \cdot 10Pa$)	0.5	1.5	2.5	4	5.5

Table 12. Standard values according to the air permeability of window

condition	1～6stories	7～30 stories
outdoor wind velocity >=3.0m/s	above Ⅲ grade	above Ⅱ grade
outdoor wind velocity <3.0m/s	above Ⅳ grade	above Ⅲ grade

Table 13. Tolerance range of difference between indoor temperature and the surface temperature of shelter

type of building and room	Exterior wall	Flat roof, inside of rgabled roof
Residential building, hospital, kindergarten	6	4
Office building, school, Clinic	6	4.5
Hall, Dining-room, gymnasium	7	5.5
Building with high humidity	ti-td=7	
Inside of exterior wall and ceiling both are not allow to be dew condensation		0.8(ti-td)
Only inside of ceiling are not allow dew condensation		0.9(ti-td)

Notes:
(1)The room with 13～14℃ indoor temperature and above 75% relative humidity, and the room with above 24℃ indoor temperature and above 60% relative humidity are defined as high humid room.
(2)ti and td respectively are indoor air temperature and dew point temperature.
(3)When people are prolonged stay in the room, the tolerance temperature difference is 2.5℃ of the slab opposed to out air and above slab of basement; otherwise, it is 5℃.

table is shown, the heat transfer coefficient value of haerbin, which located in the severe cold region of China, is about 0.5. It is still larger than that of advanced nation. On the other hand, in Japan, the thermal insulation standard has been revised twice in order to raise the thermal insulation, and China should refer the Japanese case for the standard draft from now on.

In addition, about the floor of heating residential building, the heat absorption index has been classified three grades shown in Table 10 according to attribute of building.

Airtight: according to outdoor air wind 3.0m/s in winter, China has been classified into two regions; furthermore, building also has been specified by the number of stories. The air permeability grade values for windows ware shown in Table 11. These valves are specified in the current national standard [Air Permeability of outside Windows of Building] (GB7107). The standard value according to the air permeability of window was shown in Table 12.

Prevention of moisture: Table 13 has specified the tolerance range of temperature difference between indoor temperature and surface temperature of each part of building shelter, considered the prevention of moisture respectively required about the building according to use. In addition, heat resistance measures should be adopted in the bottom of floor; and the moisture absorption materials is required for floor.

Table 14. The energy-saving synthetic index of building

Heating Degree Day HDD18 (℃·d)	Heating index q_h (W/m^2)	Yearly power consumption for heating (kWh/m^2)	Cooling Degree Day HDD26 (℃·d)	Cooling index q_c (W/m^2)	Yearly power consumption for cooling (kWh/m^2)
800	10.1	11.1	25	18.4	13.7
900	10.9	13.4	50	19.9	15.6
1000	11.7	15.6	75	21.3	17.4
1100	12.5	17.8	100	22.8	19.3
1200	13.4	20.1	125	24.3	21.2
1300	14.2	22.3	150	25.8	23
1400	15	24.5	175	27.3	24.9
1500	15.8	26.7	200	28.8	26.8
1600	16.6	29	225	30.3	28.6
1700	17.5	31.2	250	31.8	30.5
1800	18.3	33.4	275	33.3	32.4
1900	19.1	35.7	300	34.8	34.2
2000	19.9	37.9	—	—	—
2100	20.7	40.1	—	—	—
2200	21.6	42.4	—	—	—
2300	22.4	44.6	—	—	—
2400	23.2	46.8	—	—	—
2500	24	49	—	—	—

5.3 Standard of heating load in hot summer and cold winter region

The energy-saving synthetic index of building(Table 14)specified by calculating the heating and cooling load, and annual electricity used in the HVAC system. The dynamic method was used for the energy conservation calculation of residential building in hot summer and cold winter zone. The calculation conditions can be summarized as follows:

(1) indoor design air temperature: winter is 18˚C, summer is 26˚C.
(2) As for outdoor calculation weather, the typical weather year data is utilized for calculation.
(3) The ventilation is one time per hour of heating and air-conditioning system.
(4) Coefficient of performance of heat pump air-conditioner is 2.3 and the heating resource is 1.9.
(5) The heat generation from lighting is 0.0141kWh/m^2, and other heat generations are specified as 4.3W/m^2.

The annual electricity consumption for heating and air-conditioning system should not exceed the limitation value of Table 14.

6. Conclusion

In this research, the authors have carried out the research to investigate the characteristics of building energy standards of the residential building in China, Efforts have also been made to promote a better understanding of the energy policy and relevant standard for architects and building designers to achieve optimal energy efficient building design, and also for assuming the building energy consumption, assessment of the thermal environment in China. The results can mainly summarized as follows:

(1) As for the thermal environment design, the climate of China has been classified five zones.
(2) The sunlight, lighting, ventilation environment of residential building have been specified in the new standards.
(3) Prescribed the building design elements, such as layout, orientation, shape, color, plan and the type of window. In particular, the thermal insulation measures for heating system has been added in hot summer and cold winter region, which was not described in old standard.
(4) It is admitted that there is still a difference compared with the standard of many foreign countries, and the improvement in the further heat insulation performance and positive execution of the standard continue to be expected.

Reference

1) *Code of Design for Residential House*, National Standard of PRC, China Planning Press, Beijing
2) *Thermal Design Code for Civil Building, GB 50176-93*, National Standard of PRC, China Planning Press, Beijing
3) *Design Standard for Energy Efficiency of Residential Buildings in Hot Summer and Cold Winter Zone, JGJ 134-2001*, Industrial Standard of PRC, China Architecture & Building Press, Beijing.
4) *Technical Code for Renovation of Existing Heating Residential Buildings*, JGJ 129-2000, Industrial Standard of PRC, China Architecture & Building Press, Beijing
5) *Energy Conservation Design Standard for New Heating Residential Buildings, JGJ 26-86 (Trial implementation)*, Industrial Standard of PRC, China Architecture & Building Press, Beijing.
6) *Standard for Energy Efficiency Inspection of Heating Residential Buildings, JGJ 132-2001*, Industrial Standard of PRC, China Architecture & Building Press, Beijing
7) *Energy Conservation Design Standard for New Heating Residential Buildings, JGJ 26-86 (Trial implementation)*, Industrial Standard of PRC, China Architecture & Building Press, Beijing
8) *Design Code for Heating, Ventilating and Air Conditioning, GBJ 19-87*, National Standard of PRC, China Planning Press, Beijing